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(54) Name of Invention: A Digital Radio Transmission System
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(72) Inventor: Makoto Yoshimoto, c/o NEC Corp., 5-33-1 Shiba, Minato-ku, Tokyo

(71) Applicant: NEC Corp., 5-33-1 Shiba, Minato-ku, Tokyo

(74) Agent: Patent Agent: Yoshihiro Hachiman [or Yahata]

Specification

1. Name of the invention

A Digital Radio Transmission System

2. Scope of claims of patent

In connection with a digital radio transmission system which is comprised of one or multiple currently used systems and one reserve system of radio transmission lines based on multiple-value quadrature amplitude modulation method: a digital radio transmission system which is characterized by being provided with; on the transmission side in a currently used system, a transmission switch that while [operation] is switched to the reserve system, switches signal input respectively from the currently used system to the transmission system in the reserve system and from the reserve system to the transmission system in the currently used system, and makes such connections; a modulator that performs multiple-value quadrature amplitude modulation on output from this transmission switch in the currently used system, and that while [operation] is switched to the reserve system, switches to a quadrature amplitude modulation method of lower multiple-value than that of the original multiple-value quadrature amplitude modulation method; and on the receiving side in the currently used system, a selector that while [the operation] is switched to the reserve system, selects signals that relate to the above-stated reserve system signals among the received signals in the currently used system; and a demodulator that performs on the output from this [above-stated] selector demodulation based on a demodulation method that corresponds to the above-stated lower multiple-value quadrature amplitude modulation method.

3. Detailed description of the invention

(Field of [its] industrial use)

The present invention relates to a digital radio transmission system using a multiple-value quadrature amplitude modulation method, in particular to technology utilizing transmission lines in operations including reserve lines.

(Conventional technology)

As digital radio transmission system using a multiple-value quadrature amplitude modulation method such as a 64 QAM (Quadrature Amplitude Modulation) method or a 256 QAM system, for example, what is shown in Figure 6 was known conventionally.

In Figure 6, this Digital Radio Transmission System is equipped with one reserve line CH0 and currently used multiple lines (CH1 ~ CHN). The currently used system is equipped with: on the transmission side, transmission switches (61 – 1 ~ 61 – N), modulators of, for example, 64 QAM method (62 – 1 ~ 62 – N) and transmitters (63 – 1 ~ 63 – N); and on the transmission side [sic], receivers (64 – 1 ~ 64 – N), demodulators of a 64 QAM method (65 – 1 ~ 65 – N),

and receiving switches (66 – 1 ~ 66 – N).

On the other hand, the reserve system is equipped with: on the transmission side, a pilot signal generator 67, transmission switch 68, a modulator of 64 QAM method 69 and a transmitter 70; and on the receiving side, a receiver 71, a demodulator of 64 QAM method 72, a receiving switch 73 and a pilot signal detector 74.

And the configuration is such that serially connected between the output terminal of the transmission switcher 68 and the input terminal of the modulator 69 in the transmission system of the reserve system are N pieces of transmission switchers for the currently used system (61 – 1 ~ 61 – N) and that at the same time, serially connected between the output terminal of the demodulator 72 and the input terminal of the receiving switch 73 in the receiving system of the reserve system are N pieces of receiving switchers for the currently used system (66 – 1 ~ 66 – N).

The transmission switches (61 – 1 ~ 61 – N) are configured, as shown in Figure 7, in such a manner that they output input signals for the currently used system coming into the corresponding input terminals as they are to the corresponding modulators (62 – 1 ~ 62 – N) and that a switch S_1 connects either input signals for the currently used system or input signals for the reserve system to the transmission side of the reserve system. This switch S_1 is controlled in such a way that if line quality of the currently used line at issue deteriorates, switch S_1 outputs the input signals for the currently used system at issue to the transmission side of the reserve system as well.

Likewise, while the receiving switches (66 – 1 ~ 66 – N) ordinarily transmit [signals] outputted from corresponding demodulators (65 – 1 ~ 65 – N) to corresponding output terminals (#10 ~ #N0), linked to switching to the reserve system on the transmission side, corresponding receiving switches are controlled in such a manner that they transmit [signals] outputted from the demodulator 72 to the corresponding output terminals for the currently used system.

Here, deterioration of line quality is determined on the basis of signals transmitted to output terminals in the currently used system on the receiving side, and based on the result of the determination, switching of the transmission switches (61 – 1 ~ 61 – N) and receiving switches (66 – 1 ~ 66 – N) are controlled, as is known.

On the other hand, the transmission switch 68 selects and outputs either pilot signals generated by the pilot signal generator 67 or reserve system signals that come into the input terminal #0. In other words, in connection with this type of system, there are two forms of operations that utilize the reserve line CH0 in normal operation. One is a method [of operation] in which normal operation is confirmed by transmitting pilot signals and by having them detected by the pilot signal detector 74.

The other is a method of operation (Reserve Operation Method) in which the reserve line CH0 and the currently used lines (CH1 ~ CHN) are treated equally in order to effectively use frequencies and normal operation of the reserve system is confirmed at the same time by the reserve system signals transmitted to the output terminal #00. In either method, when a switch is made to the reserve system, signals on the reserve line CH0 are substituted with signals relating to the currently used lines of which line quality deteriorated, and thus connection using the currently used line is prevented from being broken.

(Problem intended to be solved by the invention)

In a conventional digital radio transmission system, the higher the values that multiple value modulation methods use, the more susceptible transmitted signals based on the multiple value modulation methods become of being affected by rainfall, fading, etc., and the more likely will the line quality be to deteriorate, so considerations are paid by providing reserve lines to prevent occurrence of disconnection of lines and also to make it possible to use a reserve operation system, to effectively use frequencies, and to improve on transmission efficiency.

If quality of currently used lines deteriorates, however, signals carried on the reserve lines by the reserve operation system must be interrupted, and besides the currently used line that deteriorated cannot be used any more, there is a problem with the conventional reserve operation method in that it is insufficient as a measure to effectively use frequencies and to attempt to improve the transmission efficiency.

The present invention was made in consideration of such a problem, and its purpose is to provide, in a system that is capable of [implementing] a reserve operation method, a digital radio transmission system which is capable of effectively utilizing frequencies and attempting to improve the transmission efficiencies by being enabled to use, as opposed to not being able to, the currently used line, even if the quality of the line deteriorated and the currently used line was switched to the reserve system.

(Means to solve the problem)

In order to accomplish the above-stated purpose, the digital transmission system in accordance with the present invention has the following configuration.

That is to say, in connection with a digital radio transmission system which is comprised of one or multiple currently used systems and one reserve system of radio transmission lines based on multiple-value quadrature amplitude modulation method: a digital radio transmission system in accordance with the present invention is characterized by being provided with;

on the transmission side in a currently used system, a transmission switch that while [operation] is switched to the reserve system, switches signal input respectively from the currently used system to the transmission system in the reserve system and from the reserve system to the transmission system in the currently used system, and makes such connections; a modulator that performs multiple-value quadrature amplitude modulation on output from this transmission switch in the currently used system, and that while [operation] is switched to the reserve system, switches to a quadrature amplitude modulation method of lower multiple-value than that of the original multiple-value quadrature amplitude modulation method; and on the receiving side in the currently used system, a selector that while [the operation] is switched to the reserve system, selects signals that relate to the above-stated reserve system signals among the received signals in the currently used system; and a demodulator that performs on the output from this [above-stated] selector demodulation based on a demodulation method that corresponds to the above-stated lower multiple-value quadrature amplitude modulation method.

(Effects)

Next, effects of the digital radio transmission system having the above-stated configuration in accordance with the present invention are explained.

During normal operations, transmission signals relating to the multiple-value quadrature amplitude modulation method are carried similarly on both reserve lines and currently used lines. Here, if during the normal operations, signals carried on the reserve lines are called reserve system signals and signals carried on the currently used lines, current system signals, and then if [something] arises causing line quality of a certain currently used line to deteriorate and the line to be switched to the reserve system, the current system signals at issue will be carried on the reserve lines by the operation of the transmission switch. On the other hand, the reserve system signals go into a modulator belonging to the transmission system of the currently used line of which line quality deteriorated, are processed with modulation based on a multiple-value quadrature amplitude modulation of lesser multiple-value than that of the proper multiple-value quadrature amplitude modulation used in normal operations, and are outputted to the currently used line that has deteriorated. In other words, the reserve system signals are not interrupted unlike in conventional cases.

Incidentally, since the reserve system signals that are transmitted thereby have been modulated by a modulation method of lesser multiple-value modulation than that of the proper modulation method, though their transmission capacity decreases, the deterioration of the line quality is minor.

Thus, the digital radio transmission method in accordance with the present invention, if [the line] is switched to the reserve system, since reserve system signals can be transmitted by use of the currently used line of which line quality deteriorated without any interruption, provides advantages of effective use of frequencies and of improvement on transmission efficiency.

(Embodiments)

Embodiments in accordance with the present invention are explained with references to figures as follows.

Figure 1 shows a digital radio transmission method relating to one embodiment of the present invention. Incidentally, components that are the same as those in the conventional technology are given the same designations [as in the conventional technology] and their explanation is omitted.

In Figure 1, in accordance with the present invention, on the transmission side, each of N number of currently used systems is equipped with a transmission switch (1 – 1 ~ 1 – N) and a modulator (2 – 1 ~ 2 – N) equipped with both 64 QAM and 4 PSK methods in lieu of a conventional transmission switch (61 – 1 ~ 61 – N) and 64 QAM modulator (62 – 1 ~ 62 – N); and on the receiving side, it has a distributor (3 – 1 ~ 3 – N) provided between a receiver (64 – 1 ~ 64 – N) and a 64 QAM demodulator (65 – 1 ~ 65 – N) and is equipped with a selector 4, 4 PSK demodulator 5 and a receiving switch 6.

The transmission switch (1 – 1 ~ 1 – N) is equipped with, as shown in Figure 2, a switch S_2 in addition to a conventional switch S_1, and the switch S_2 normally connects inputted reserve system signals to the transmission side of the reserve system in normal operation and to the transmission side of the currently used system when the line is switched to the reserve system.

Next, Figure 3 shows a configuration example of a modulator in accordance with the present invention. In this embodiment, the proper multiple-value quadrature amplitude modulation method is, for example, 64 QAM method, the same as in a conventional example, and a multiple-value quadrature amplitude modulation method with lesser multiple-value than this is a 4 PSK (4-Phase Shift Keying) method.

In addition, though omitted in Figure 1 (the same in Figure 6 which is a conventional figure) in order to simplify explanation, current system signals applied to each of input terminals #1 ~ #N are comprised of multiple -bit signals arranged in parallel.

For example, a hierarchy DS (digital system) – 3 is a system wherein three rows of signals with a bit rate of 45 Mbps are handled in parallel, and Figure 3 shows a modulator configuration example when [the present invention] is considered applied to this system.

In Figure 3, 31 ~ 33 are 1 – 2 Converters; 34, Difference Conversion Circuit; 35, 64 QAM/4 PSK Converter; 36, D –A Converter; 37 and 38,

Low Pass Filters; 39, a Local Oscillator; 40 and 44, hybrid; 41 and 43, Mixers; 42, π/2 Phase Shifter; and 45, an amplifier.

The 1 – 2 Converters convert respectively corresponding input signal rows (first ~ third signal rows) into 2-bit signals arranged in parallel. Output from 1 – 2 Converter 31 is outputted to the differential conversion circuit; output (DATA1 ~ ditto 4) from 1 – 2 converters 32 and 33 are outputted respectively to 64 QAM/4 PSK Converter 35. Since operation of the differential conversion circuit is well known, its explanation is omitted, and its output, phase component signals I_1 and quadrature component signals Q_1 are outputted to the 64 QAM/4 PSK Converter 35 and D – A Converter 36.

The 64 QAM/4 PSK Converter 35 is configured, for example, as shown in Figure 4, and in accordance with switching signals given from outside, its output, phase component signals I_2 and I_3 and quadrature component signals Q_2 and Q_3 are outputted to D – A Converter 36. In Figure 4, switching signals are applied as input on one side of And Gates 56, 55, 54, and 53, and are also applied as input on one side of And Gates 52 and 51 via an Inverter 57. And the phase component signals I_1 are applied as input on the other side to the And Gate 51 and the quadrature component signals Q_1 are applied as input on the other side to the And Gate 52.

Also, DATA1 is applied as input on the other side to the And Gate 53; DATA2, as input on the other side to the And Gate 54; DATA3, as input on the other side to the And Gate 55; and DATA4, as input on the other side to the And Gate 56. Next, in the output stage, an Or Gate 58 receives, as input, output from the And Gate 51 and output from the And Gate 53 and outputs Phase Component Signal I_2; an Or Gate 59 receives, as input, output from the And Gate 52 and output from the And Gate 54 and outputs Quadrature Component Signal Q_2; an Or Gate 60 in the output stage receives, as input, output from the And Gate 51 and output from the And Gate 55 and outputs Phase Component Signal I_3; and an Or Gate 61 receives, as input, output from the And Gate 52 and output from the And Gate 56 and outputs Quadrature Component Signal Q_3.

In sum, in this 64 QAM/4 PSK Converter 35, a switching signal which is input from outside is created on the basis of line quality of the currently used line, and it is set at "1" level during normal operation, so if [signals on] the currently used line showing deterioration of line quality are detected, only [a switching signal] that is supplied to the modulator on the transmission side of the currently used system is changed to "0" level. Since the And Gate 51 and And Gate 52 are prohibited from transmitting an output when this switching signal is at the "1" level, Phase Component Signal I_2 that relates to DATA1; Phase Component Signal I_3 that relates to DATA3; Quadrature Component Signal Q_2 that relates to DATA2; and Quadrature Component Signal Q_3 that relates to DATA4; are outputted. Accordingly, supplied as input to the D – A Converter 36 are 3 bits that are Phase Component Signals I_1, I_2, and I_3 and 3 bits that are Quadrature Component Signals Q_1, Q_2 and Q_3. In other words, a signal point layout on the phase plane of 8-digit + 8-digit digital signals that are input to the D – A Converter 36 will be in accordance with the 64 QAM Method as shown in Figure 5(a).

On the other hand, when the switching signal is at the "0" level, since conversely to what is described above, setting will be made such that the And Gates 53 ~ 56 are prohibited from transmitting an output, Phase Component Signals I_2 and I_3 become the same as Phase Component Signal I_1 and likewise, Quadrature Component Signals Q_2 and Q_3 become the same as Quadrature Component Signal Q_1. Accordingly, input to the D – A Converter 36 become the Phase Component Signal I_1 and Quadrature Component Signal Q_1. In other words, a signal point layout on the phase plane of 2-digit + 2-digit digital signals that are input to the D – A Converter 36 will be in accordance with the 4 PSK Method as shown in Figure 5(b).

As stated above, while major causes of deterioration of line quality include rainfall and fading, one can see clearly in Figure 5 that the 4 PSK Method which is a modulation method of less values is more resistant to the major causes of deterioration than the 64 QAM Method which is a modulation method of higher values. In addition, in the above-stated conversion example, since 3 outputs are used as 1 input, when [operation] is switched to the reserve system, transmission capacity of the reserve system signals is 1/3. In other words, if the high-value modulation method handles 2^m values and the low-value modulation method handles 2^n, when [the operation] is switched to the reserve system, the possible transmission capacity becomes n/m.

Incidentally, the D – A Converter 36 converts into analog signals Phase Component Signal I (I_1, I_2, I_3 or I_1) and Quadrature Component Signal Q (Q_1, Q_2, Q_3 or Q_1) each.

These become input on one side to the Mixers 41 and 43 via respective corresponding Low Pass Filters 37 and 38. On the other hand, local signals generated by Local Oscillator 39 are divided into two by Hybrid 40 and one is inputted as the other input to Mixer 41 and the other goes through the π/2 Phase Shifter 42 and is inputted as the other input to Mixer 43. Mixers 41 and 43 convert inputted base band signals into signals in the IF (intermediate frequency) band based on the local signals. These output [signals] are synthesized by Hybrid 44 and amplified up to a certain prescribed level by Amplifier 45. The IF output is input to Transmitters (63 – 1 ~ 63 – N).

Next, in Figure 1, on the receiving side of the currently used system, output from Receivers (64 – 1 ~ 64 – N) is divided into two by Hybrids (3 – 1 ~ 3 – N), and one is supplied to Demodulators (65 – 1 ~ 65 – N) that are the same as in the conventional [technology], and the other is inputted to Selector 4 altogether.

As is known, a determination as to whether or not line quality of the currently used line is good is made in the base band processing system on the receiving side. And if as a result it is determined that switching from one currently used line to the reserve system is necessary, that information is communicated to the transmission side. So, on the transmission side, what is specified among Transmission Switches 1 – 1 ~ 1 – N is switch-controlled, and at the same time, the above-stated signal switching to a modulator corresponding thereto among Modulators 2 – 1 ~ 2 – N is operated. On the other hand, identification information on line number of the currently used number that was switched to the reserve system is given to Selector 4 on the receiving side. Thereupon, Selector 4 selects, out of N signals inputted from N pieces of Hybrids (3 – 1 ~ 3 – N), a received signal that relates to the currently used line that became a problem, and outputs it to Demodulator 5 of the 4 PSK Method.

What relates to 1 signal row out of 3 signal rows of reserve system signals applied to Input Terminal #0 has been processed with 4 PSK modulation and carried on the currently used line at issue is demodulated by Demodulator 5, goes through Receiving Switches 6 and 73, and is outputted to Output Terminal #0 for the reserve system signals.

(Effect of Invention)

As described in detail above, in connection with a Digital Radio Transmission System in accordance with the present invention, a modulator provided on the transmission side of the currently used system is configured in such a manner that an original multiple-value quadrature amplitude modulation method that is used during normal operation can be switched with a multiple-value quadrature amplitude modulation method of which multiple values are less than that of the original multiple-value quadrature amplitude modulation method, and that while it is switched to the reserve system, reserve system signals can be modulated by the modulator of the transmission system in the currently used system at issue that was switched to the reserve system in the modulation method based on the above-stated less multiple-value quadrature amplitude modulation method and can be outputted to the currently used line at issue, so even if it is switched to the reserve system, the currently used line, quality of which deteriorated, will not be unused and thus, frequencies can be used more efficiently.

Also, although capacity in transmission of the reserve system signals decreases, the transmission does not get interrupted as in the case of the conventional technology, so there is an advantage of improvement of transmission efficiency over the conventional technology. Incidentally, the following can be stated about the transmission capacity of the reserve system signals. If a transmission capacity processed by the original multiple-value quadrature amplitude modulation method during the normal operation is 2^m, and if a transmission capacity processed by the lower multiple-value quadrature amplitude modulation method during the operation switched to the reserve system is 2^n ($m > n$), [the reserve system] can be operated during the switched operation at the transmission capacity being n/m of the capacity of the normal operation.

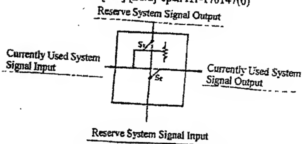
4. Simple Explanation of Figures

Figure 1 is a structural block diagram of a digital radio transmission system relating to one embodiment of the present invention. Figure 2 is a concept diagram of a transmission switch in accordance with the present invention. Figure 3 is a structural block diagram showing one example of a modulator in accordance with the present invention. Figure 4 is a circuit diagram of 64 QAM/4 PSK Converter in Figure 3. Figure 5 shows signal point layout drawings of [signals] of 64 QAM Method and 4 PSK Method. Figure 6 is a structural block diagram in accordance with a conventional digital radio transmission system. Figure 7 is a concept diagram of a conventional Transmission Receiving Switch.

1 – 1 ~ 1 – N ······ Transmission Switches, 2 – 1 ~ 2 – N ······ 64 QAM/4 PSK Modulators, 3 – 1 ~ 3 – N ······ Hybrids, 4 ······ A Selector, 5 ······ A 4 PSK Demodulator, 6 ······ Receiving Switch, 63 – 1 ~ 63 – N ······ Transmitters, 64 – 1 ~ 64 – N ······ Receivers, 65 – 1 ~ 65 – N ······ 64 QAM Demodulators, 66 – 1 ~ 66 – N ······ Receiving Switches, 67 ······ A Pilot Signal Generator, 68 ······ A Transmission Switch, 70 ······ A Transmitter, 71 ······ A Receiver, 72 ······ A 64 QAM Demodulator, 73 ······ A Receiving Switch, 74 ···········

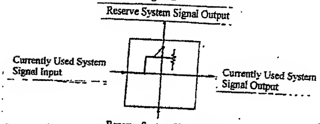
A Pilot Signal Detector, CH0 ----- A Reserve Line, CH1 ~ CHN ----- Currently Used Lines

Representative Patent Agent Yoshihiro Hachiman [or Yahata]



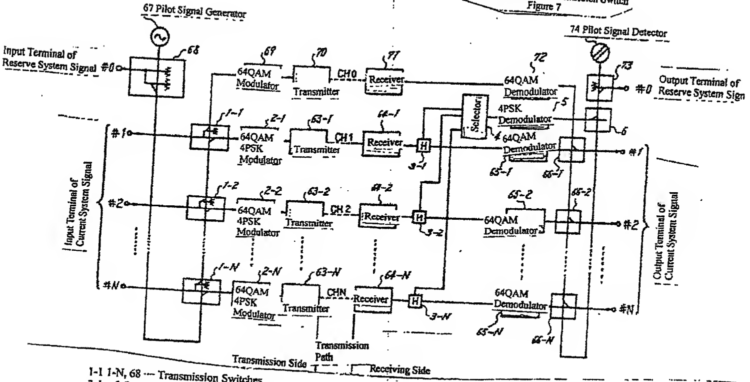
Transmission Switch in accordance with the Present Invention

Figure 2



Conventional Transmission Switch

Figure 7

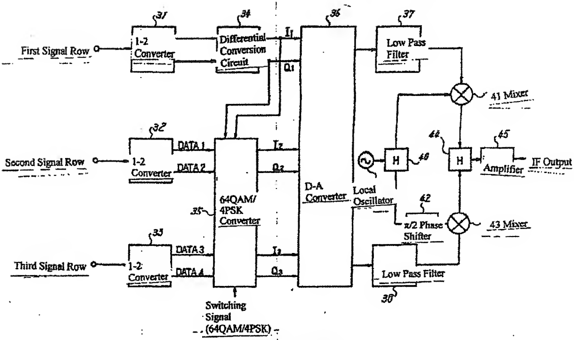


1-1 1-N, 68 --- Transmission Switches

3-1 ~ 3-2 ··· Distributor

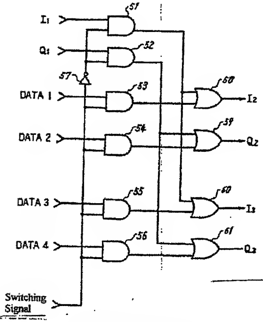
6, 66-1 ~ 66-N, 73 ---- Receiving Switches

A Configuration Example of a Digital Radio Transmission System in accordance with the Present Invention



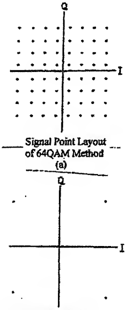
A Configuration Example of a Modulator in accordance with Present Invention

Figure 3



64QAM/4PSK Converter

Figure 4



Signal Point Layout of 64QAM Method

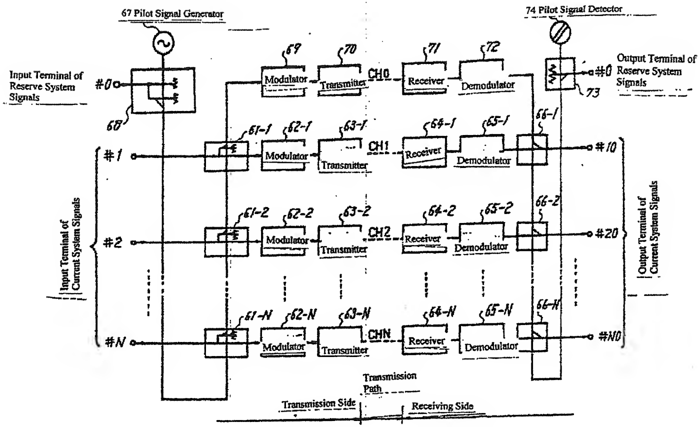
(a)

Signal Point Layout Of 4PSK Method

(b)

Signal Point Layout Drawing Of 64QAM/4PSK Methods

Figure 5



68, 61-1 ~ 61-N ···· Transmission Switch
66-1 ~ 66-N, 73 ···· Receiving Switch
A Configuration Example of Conventional Digital Radio Transmission System
Figure 6